

## CLAIMS

What is claimed is:

- 1     1.     A system, comprising:  
2           a holographic optical element (HOE) device having:  
3               a first element having first and second surfaces, the first surface being  
4               positionable to face incident light rays;  
5               an emulsion material disposed over the second surface of the first  
6               element and having a recorded interference pattern thereon; and  
7               a second element having a first surface disposed over the emulsion  
8               material, the second element being structured to pass resulting light rays,  
9               derived from the incident light rays diffracted by the recorded interference  
10              pattern, in a direction towards a location facing a second surface of the  
11              second element; and  
12              an optical processing unit to receive the resulting light rays passed by the  
13              second element.
  
- 1     2.     The system of claim 1, further comprising a transmitter unit disposed at least  
2           in part behind the second surface of the second element.
  
- 1     3.     The system of claim 2 wherein the emulsion material is shaped to provide an  
2           opening through which to pass a light signal sent from the transmitter unit.
  
- 1     4.     The system of claim 2 wherein the transmitter unit comprises:  
2           an optical fiber capable to provide a light signal;

3 a first and a second optical element to expand the light signal provided by the  
4 optical fiber;

5 a third optical element to control divergence of the expanded light signal; and

6 a fourth optical element to collimate light that exits from the transmitter unit.

1 5. The system of claim 1, further comprising a plurality of mirrors positionable  
2 between the HOE device and the optical processing unit, the plurality of mirrors  
3 being capable to reduce an overall focal length of the HOE device by controlling a  
4 direction of the resulting light rays passed from the second element of the HOE  
5 device.

1 6. The system of claim 1, further comprising a steering mirror positionable  
2 between the HOE device and the optical processing unit, the steering mirror being  
3 capable of substantially keeping the resulting light rays focused towards the optical  
4 processing unit in response to movement of the HOE device.

1 7. The system of claim 1, further comprising:  
2 an optical detector; and  
3 a beam splitter to direct a first portion of the resulting light rays associated  
4 with a tracking operation towards the optical detector and to direct a second portion  
5 of the resulting light rays having data modulated thereon towards the optical  
6 processing unit.

1 8. The system of claim 1, further comprising:  
2 a collimating optical assembly positionable between the HOE device and the  
3 optical processing unit to collimate the resulting light rays; and

an optical element positionable between the collimating optical assembly and the optical processing unit to separate, from the collimated resulting light rays, a tracking channel and a communication channel, and to direct the communication channel towards the optical processing unit.

9. The system of claim 8 wherein the collimating optical assembly includes a movable refocusing element to longitudinally refocus the collimated resulting light rays.

10. The system of claim 9 wherein the refocusing element is movable via motor control.

11. The system of claim 8 wherein the collimating optical assembly includes a plurality of lenses to correct aberrations in the resulting light rays.

12. The system of claim 8 wherein the optical element comprises a monolithic optical element, the monolithic optical element including:

a lens to refract the resulting light rays;

a first element, coupled to the lens and coupled to a second element at an interface, to receive the refracted light rays from the lens;

a beam splitter disposed at the interface between the first and second element to direct the refracted light rays to the tracking channel and to the communication channel; and

a third element coupled to the second element, the third element having a reflective surface to reflect the refracted light rays of the communication channel towards the optical processing unit.

1 13. The system of claim 1 wherein the optical processing unit includes a  
2 photodetector to convert the resulting light rays received from the second element  
3 into electronic signals.

1 14. The system of claim 1 wherein the recorded interference pattern comprises a  
2 volume phase hologram.

1 15. The system of claim 1, further comprising a spotting scope usable for  
2 alignment adjustment of the HOE device.

1 16. The system of claim 15 wherein the emulsion material is shaped to provide a  
2 substantially unobstructed field-of-view for the spotting scope.

1 17. The system of claim 15 wherein the spotting scope is disposed at least in part  
2 behind the second surface of the second element.

1 18. The system of claim 15 wherein the spotting scope includes an image sensor.

1 19. The system of claim 1, further comprising an alignment beacon.

1 20. The system of claim 19 wherein the emulsion material is shaped to provide a  
2 substantially unobstructed opening for the alignment beacon.

1 21. The system of claim 19 wherein the alignment beacon is disposed at least in  
2 part behind the second surface of the second element.

1 22. The system of claim 19 wherein the alignment beacon is capable of being  
2 provided along with a transmit light signal along a same optical fiber.

1 23. An apparatus, comprising:  
2 a holographic optical element (HOE) device disposed in a receiver unit, the  
3 HOE device including a recorded interference pattern, the HOE device being  
4 positionable to face incident light rays and being capable of passing the incident  
5 light rays as resulting light rays diffracted by the recorded interference pattern.

1 24. The apparatus of claim 23, further comprising a transmitter unit disposed at  
2 least in part behind the HOE device.

1 25. The apparatus of claim 23 wherein the receiver unit includes:  
2 an optical processing unit to receive the resulting light rays; and  
3 a plurality of mirrors between the optical processing unit and the HOE device  
4 to control a direction of the resulting light rays from the HOE device to the optical  
5 processing unit.

1 26. The apparatus of claim 23, further comprising:  
2 a collimating optical assembly positionable between the HOE device and an  
3 optical processing unit to collimate the resulting light rays; and  
4 an optical element positionable between the collimating optical assembly and  
5 the optical processing unit to separate, from the collimated resulting light rays, a  
6 tracking channel and a communication channel, and to direct the communication  
7 channel towards an optical processing unit.

1 27. The apparatus of claim 26 wherein the optical element comprises a  
2 monolithic optical element, the monolithic optical element including:

3 a lens to refract the resulting light rays;

4 a first element, coupled to the lens and coupled to a second element at an  
5 interface, to receive the refracted light rays from the lens;

6 a beam splitter disposed at the interface between the first and second  
7 element to direct the refracted light rays to the tracking channel and to the  
8 communication channel; and

9 a third element coupled to the second element, the third element having a  
10 reflective surface to reflect the refracted light rays of the communication channel  
11 towards an optical processing unit.

1 28. The apparatus of claim 24, further comprising an emulsion material having  
2 the interference pattern recorded thereon, wherein the emulsion material is shaped  
3 to provide an opening through which to pass a light signal sent from the transmitter  
4 unit.

1 29. The apparatus of claim 23, further comprising a spotting scope disposed at  
2 least in part behind the HOE device.

1 30. The apparatus of claim 23, further comprising an alignment beacon.

1 31. The apparatus of claim 23, further comprising an emulsion material having  
2 the interference pattern recorded thereon, wherein the emulsion material is shaped

3 to provide a center obscuration to allow the HOE device to collect the incident light  
4 rays into a cone.

1 32. An apparatus, comprising:

2 a holographic optical element (HOE) device disposed in a receiver unit, the  
3 HOE device including an interference pattern recorded on an emulsion material; and

4 a transmitter unit disposed at least in part behind the HOE device, the  
5 emulsion material being shaped to allow transmission of a light signal from the  
6 transmitter unit through the HOE device, substantially unaffected by the recorded  
7 interference pattern.

1 33. The apparatus of claim 32 wherein the transmitter unit comprises:

2 an optical fiber capable to provide the light signal;

3 a first and a second optical element to expand the light signal provided by the  
4 optical fiber;

5 a third optical element to control divergence of the expanded light signal; and

6 a fourth optical element to collimate light that exits from the transmitter unit.

1 34. The apparatus of claim 32, further comprising a spotting scope usable for  
2 alignment adjustment.

1 35. The apparatus of claim 34 wherein the emulsion material is shaped to provide  
2 a substantially unobstructed field-of-view for the spotting scope.

1 36. The apparatus of claim 34 wherein the spotting scope is disposed at least in  
2 part behind the HOE device.

1 37. The apparatus of claim 34 wherein the spotting scope includes an image  
2 sensor.

1 38. The apparatus of claim 32, further comprising an alignment beacon.

1 39. The apparatus of claim 38 wherein the alignment beacon is disposed at least  
2 in part behind the HOE device, and wherein the emulsion material is shaped to  
3 provide a substantially unobstructed opening for the alignment beacon.

1 40. The apparatus of claim 38 wherein the alignment beacon is capable of being  
2 provided with the light signal from the transmitter unit along a same optical fiber.

1 41. The apparatus of claim 32 wherein the emulsion material is shaped to provide  
2 a region devoid of emulsion material, wherein the region allows a substantially  
3 unobstructed passage of the light signal from the transmitter unit and a substantially  
4 unobstructed field-of-view of a spotting scope disposed at least in part behind the  
5 HOE device.

1 42. A method, comprising:  
2 positioning a transmitter unit at least in part behind a holographic optical  
3 element (HOE) device including an interference pattern recorded on an emulsion  
4 material, the part of the transmitter unit being positioned behind an opening in the  
5 emulsion material; and



6           transmitting a light signal from the transmitter unit through the opening in the  
7   emulsion material, the transmitted light signal being substantially unaffected by the  
8   recorded interference pattern.

1   43.   The method of claim 42, further comprising using a spotting scope in  
2   connection with alignment adjustment related to the transmitted light signal.

1   44.   The method of claim 42, further comprising using an alignment beacon in  
2   connection with alignment adjustment related to light rays incident on the HOE  
3   device.